HiSparc Bristol plan

HiSparc is a very successful outreach project for high school students to participate in real research on cosmic rays. In Holland there are about 100 schools participating and many more on the waiting list. The programme has been rolled out in other countries as well. Our plan is to roll our HiSparc in the wider Bristol area and make use of the existing infrastructure and know-how of our Dutch colleagues.

The Physics

The Earth is continuously bombarded by high energy particles coming from outer space. The first serious experiments have been done in 1912, when Victor Hess went up in a balloon to measure the rates of these particles. These particles generate showers in the atmosphere. The sources of these particles in terms of physics processes and production locations are still not well known. Also the rates at which the high energy ones occur is not well known. The physics behind the showers is easy to understand for high school students and involves physics that students usually find very exciting but is not rigorously taught as part of the standard curriculum (relativity, quantum mechanics, elementary particles). Large scientific collaborations are studying the rates of the (ultra) high energy showers.

Showers are measured by looking for coincidences between hits in the detectors. Time differences give information on the angle that the shower makes with respect to the detector system. Measuring the total pulse height of the signals in the detectors gives a density profile that allows a reliable estimation of the shower energy. For the latter to work (and this is where the most interesting physics is) the ideal set up is a set of detectors making triangles with a side of ~1km. In an ideal case this can be three schools, or a school, a library and a university building, etc.

Some of the simple physics one can do is measuring rates as a function of energy, rate variations as a function of the time of day, rate versus latitude, angular dependence of showers, looking for sources, etc. Many HiSparc systems now also have a weather station integrated as there are many models predicting different rates of cosmic particles depending on the weather; especially thunder storms. It should be noted that HiSparc is NOT is system/project with a limited physics reach. The aim and key to their success is that none of the physics studied is text book research. HiSparc combines outreach with proper research. The students actually do serious, new research and do not go through a list of plots that they can make and are then finished. For example, there are serious physics models that predict energetic showers occurring simultaneously that are separated by up to ~40km. Currently, there are not many detector systems that can measure those.

The main idea

Cosmic ray detectors are placed on schools. These detectors are delivered as DIY kits. That means that the students build the systems themselves under supervision of an academic. The kit contains all the parts needed build the system including cables, material to fix the boxes to the roof, etc. All the school needs to provide is power, a PC and an internet connection. The system comes either with 2 or with 4 detectors.

The data is written to a central database. The students work in a large collaboration and develop analysis tools in JAVA. These tools and all the data are made available to the entire community. The DAQ soft- and firmware is automatically updated remotely, so the schools do not have to do anything for that. HiSparc experts can also remotely log in to a station and study its performance and diagnose problems.

Besides the detector system HiSparc has developed a large amount of teaching material that teaches students, between the ages of 13 to 18 in the Dutch educational system, about the basic physics underpinning this experiment. These teaching programmes are currently being translated into English.

The cost

In the Netherlands the schools purchase the system. They systems cost E5000. This will be paid for partly by the school, partly by grants, partly by sponsoring and partly by the university. The schools will agree a long term payment plan to pay for their share.

The data

The detector systems continuously send their data to the central data base. This also allows continuous monitoring of the system. On the website of HiSparc it is immediately visible to all members that a detector is not working. The local responsible person is immediately warned by email that the system has problems. So far only in one case has HiSparc taken a detector system back because it was not used[1]. The other systems have all been up and running almost continuously since starting the project. The ``oldest'' schools joined approximately 10 years ago.

Role of the university

The role of the central organisation is to facilitate the project. The key persons are the high school teachers themselves who need to motivate the students every year for the project. In the Netherlands many enthusiastic teachers have been found. They find it exiting to teach the physics from after 1900 and to take part in a real research project. HiSparc has secured funding to buy out approximately 10 teachers a year for one day a week to work on the development of teaching materials. HiSparc also uses the Teachers at CERN programme where teachers can go for a master class in particle physics. Many teachers have also started to use the project as extra teaching for ``elite'' students, i.e if a student has the grades, they are allowed to join. This has worked remarkably well.

The central organisation facilitates by continuously monitoring the status of the detectors, by running the central data base and by providing expert help on physics questions. Furthermore, annual conferences are organised, students come for extra lab sessions, extra lectures and special seminars.

Physics with a single detector system

When a single school has a system and is further away than ~1km from other systems, no shower energy can be measured, although from the detector signals estimates can be made. However, the data is still useful for large range correlation studies, for producing source maps etc. These schools will also have access to the central database of data and analysis tools and can therefore still fully participate in the collaboration. However, in an ideal case we make triangles of systems at appropriate distances.

Why now? Why here?

As described before, in 1912 Victor Hess started his famous balloon experiments to measure cosmic ray fluxes at various altitudes. Next summer that will be exactly 100 years ago. In 1947 Cecil Powell, while working in Bristol, discovered the pion in balloon experiments and got a Nobel prize for it.

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[1] This was because the physics teachers had a disagreement with the board and went to a different school. The new teachers did not want to join the programme.

We want to launch our programme now, so that we can have the first few schools work on this project at least for a couple of months. Then we can organise a conference next May and have as a first prize for the best project a balloon trip to recreate one of Hess' experiments during the Bristol balloon fiesta in August 2012. This would then be a great occasion to get more publicity for our project and the university.

Implementation

The physics department will install a double system, i.e. four detector units, on the roof of the Social Sciences Library. We will organise an event for physics teachers in and around Bristol in September. Here we will present the project and show what a detector system looks like.

We want to start this fall and get things running. We want to set up an online event display in @ Bristol. This will show the showers and energy that land on Bristol super imposed on a Google Earth image of Bristol. Also we want to support the project through the Physics students on the PEU. These students need to go to local high schools and implement a science project in the schools. This obviously will be the HiSparc project.

In the spring we will organise a HiSparc Bristol conference. The best research project will win a balloon flight during the Balloon Fiesta to recreate Victor Hess' experiment.

Why would you want to join?

Teachers

- School teachers would be able to participate in a genuine research programme. Developing their subject specific knowledge and hopefully their interest in their subject.
- There are links to the particle physics content in the curriculum but also to current research topics.
- We will provide material for continuing Professional Development.
- We will try to send them to CERN for the High School Teachers at CERN programme.

Students

- The students will participate in real science; not a textbook exercise.
- They will be part of a large international collaboration, opening the possibilities of student exchange.
- Some of them will win a balloon trip or a trip to CERN.